Physics of Dislocation Patterning and Size Effects in Plasticity

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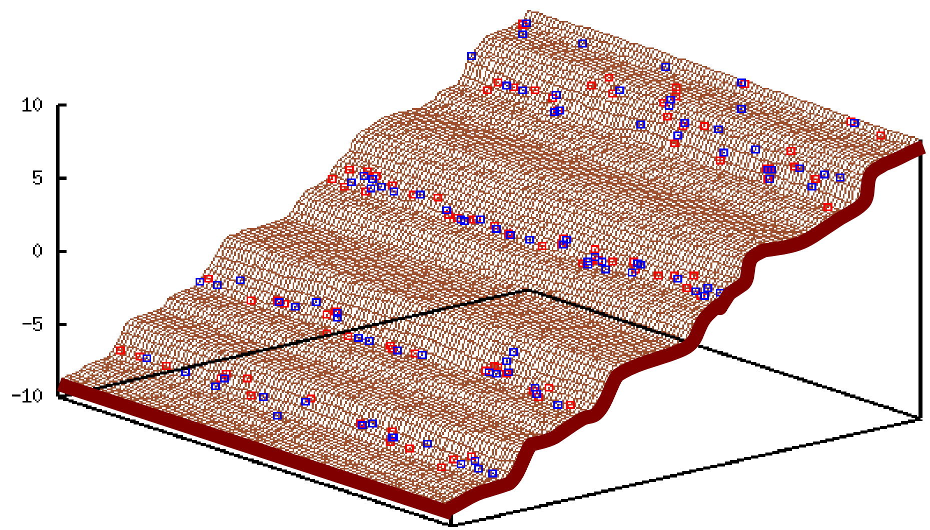
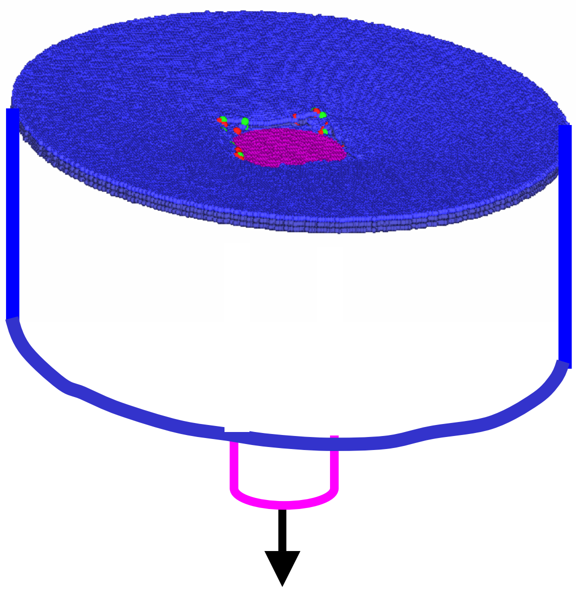
When a piece of metal is bent, crystal defects known as dislocations, shown here in red and blue, move through the material and spontaneously form patterns. The details of this process control the mechanical response of different types of metals and metal alloys. To investigate the forces driving pattern formation, we study the nucleation of dislocation-rich slip-bands in a single crystal deformed in an idealized two-dimensional geometry.





By simulating non-uniform deformation, e.g. pulling a fiber through a ductile matrix, we identify mechanisms that give small samples (of size 10-100 microns) anomalously high strength. We find that the yield stress for onset of plastic deformation is far higher near the edge of a sample than in the bulk.